AMBIENT AIR QUALITY
IN
WINDSOR AND VICINITY

Annual Report 1984

Ministry
of the
Environment
Ontario

AMBIENT AIR QUALITY
IN
WINDSOR AND VICINITY

Annual Report 1984

Technical Support Section
Southwestern Region

ONTARIO MINISTRY OF THE ENVIRONMENT
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SUMMARY

The Ministry's air quality monitoring program conducted in the Windsor area revealed satisfactory air quality with respect to many air pollutants including sulphur dioxide, carbon monoxide and nitrogen dioxide. In general, levels of air pollutants have been much lower in recent years.

Localized areas of elevated suspended particulates persisted in 1984. Excessive levels were again measured in the vicinity of the casting plant of Ford Motor Company of Canada, Limited and additional controls for emissions have been requested. At station 12015 in west Windsor suspended particulate levels were much greater in 1984 compared to 1983. Sources affecting the levels at station 12015 are the Canadian Salt Company Limited, industries in Wayne County, Michigan, and sources that contribute to the long-range transport of fine particulates.

Monitoring near Zalev Bros. Ltd. did not reveal unsatisfactory levels of suspended particulates but the monitoring network was increased in 1985 to better determine the area of impact of emissions from the operations of Zalev Bros. Ltd.

Elevated levels of total reduced sulphur, a class of malodorous compounds, were detected in west Windsor during 1984. The evaluation of this data with meteorological data indicates that the coking ovens of the steel industry in Wayne County, Michigan are the primary sources of the malodours.

Frequent excursions were again detected for the desirable ambient air quality criterion established for ozone, the most abundant photochemical oxidant in ambient

air. The elevated levels are partly a result of local emissions but to a greater degree are a result of long-range transport of oxidants and precursor chemicals into the Windsor area. Ontario has established a special program to study the oxidant situation and to develop an appropriate control strategy. The U.S. Environmental Protection Agency is requiring individual states to implement oxidant control strategies by the end of 1987.

INTRODUCTION

The Ontario Ministry of the Environment operates a network of ambient air monitors in the Windsor area to measure levels of a number of pollutants that may adversely affect health, vegetation and the enjoyment of property. Data on the levels of pollutants are compared with Ontario's criteria for desirable ambient air quality. Data are also used to determine trends in air quality and therefore, the effectiveness of pollution abatement. As well, information is provided on the effects of specific sources of pollutants and for use in the formulation of strategies to control emission sources. The air monitoring program is complemented by the Ministry's phytotoxicology surveys which determine effects of air pollutants on vegetation.

One situation not addressed by the routine air monitoring program is the malodours in the vicinity of the Chrysler plant. The Ministry used the mobile monitoring van TAGA (Trace Atmosphere Gas Analyzer) to try to identify the specific compounds causing the odours. The results of the TAGA survey are available from the Windsor District Office of the Ministry.

Another situation not thoroughly addressed by the routine air monitoring network in 1984 was particulate levels in the environs of Zalev Bros. Additional monitors were installed in 1985 to better define air quality in this area.

This annual report deals specifically with ambient air quality in the Windsor area. Detailed information on pollution abatement activities may be obtained from the Windsor District Office.

DESCRIPTION OF MONITORING NETWORK

The Ministry operates continuous and intermittent ambient air monitors at fixed sites throughout the Windsor area. Ideally, monitoring would be conducted at the same sites year after year in order to provide a historical trend for air quality. However, many stations have had to be relocated or terminated because of local interferences or changing land-use patterns. Nevertheless, the number of existing historical stations is deemed adequate to evaluate the long-term trend in levels of pollutants.

Monitoring sites are distributed more densely in the downtown area where emissions from motor vehicles and commercial establishments are more prevalent and in west Windsor, which is close to a heavily industrialized portion of Wayne County, Michigan. In 1984 the Ministry took over the operation of two sulphur dioxide monitoring sites which were previously operated by Ontario Hydro. Ontario Hydro terminated the operation of four other sulphur dioxide monitoring sites following the termination of power generation at the J. Clark Keith station.

In the spring of 1984 a change in land use forced the Ministry to stop monitoring at station 12032, located at the Morton Dock area of west Windsor. The monitoring equipment was relocated to a new site, station 12007, located on property of the City of Windsor at Water and Wright Streets in west Windsor.

At station 12013, located near the casting plant of Ford Motor Company of Canada, Limited, a total reduced sulphur monitor was installed in April, 1984. This monitor provides information on odorous compounds such as hydrogen sulphide and mercaptans.

The location of the Ministry's monitoring stations in the Windsor area are indicated on Figure 1 and are described in Table A1 of Appendix 1.

The pollutants monitored at the various stations are listed in Appendix 1, Table A2. Ontario's criteria for desirable ambient air quality with respect to these pollutants and the prime factors supporting these criteria appear in Appendix 1, Table A3.

METEOROLOGICAL DATA

Meteorological data for 1984 were obtained from station 12001 in west Windsor. Wind speed and direction are measured continuously 80 metres above ground level. The data are telemetred 12 times per hour to a computer of the Ministry in Toronto.

At station 12001 difficulties have been experienced in obtaining the desirable amount of valid data. The tower has been frequently struck by lightning and in 1984 approximately 13 percent of the meteorological data was lost. The Ministry is investigating relocating the meteorological equipment to a different site and type of tower in order to reduce data loss caused by lightning.

Meteorological data are correlated with other pollutants such as suspended particulates, sulphur dioxide and ozone to determine sources of pollutants. The data are also used to forecast dispersion conditions in association with the Air Pollution Index.

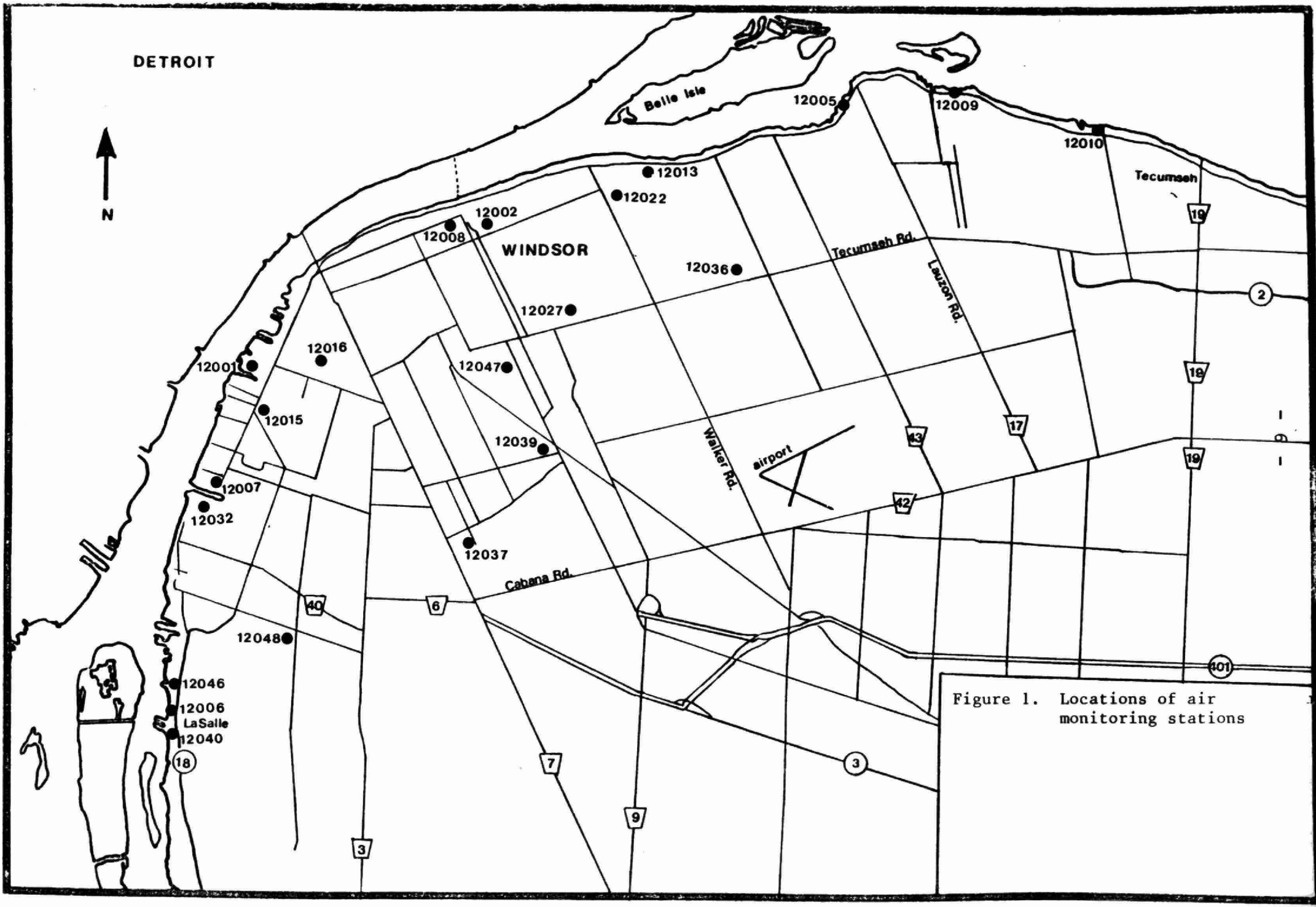


Figure 1. Locations of air monitoring stations

MONITORING AND PROGRAM RESULTS

PARTICULATES

The iron and steel industry, foundries, power generating plants utilizing fossil fuels and road traffic are primary sources of particulates that adversely affect air quality in Windsor. Wind-blown particulates from open fields, sand and coal piles, roadways and roofs are also significant sources.

Measurements for particulates are reported as suspended particulates, dustfall and soiling index. Levels of suspended particulates are determined by drawing measured volumes of air through a filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter. A Hi-Vol sampler draws a large volume of air through a filter and is used to determine levels of total suspended particulate matter. A dichotomous sampler simultaneously collected suspended particulates in a coarse size fraction and a fine size fraction. The coarse size fraction contains particulates between 10 and 2.5 microns based on cut-points of 50 percent mass median diameters. The fine fraction contains particulates less than 2.5 microns. The majority of particulates inhaled by humans are less than 10 microns in diameter but most particles greater than 2.5 microns are removed by the body's natural protection system. The dichotomous sampler was part of an experimental program and at this time the results are not considered valid air quality data and therefore, are not reported.

Dustfall is measured by exposing an open cylinder (jar) of known diameter for 30 days and subsequently weighing the amount of particulates collected in the jar.

Soiling index is determined by measuring the difference in the amount of light transmitted through a filter before and after ambient air is drawn through the filter for 1 hour. The amount of light transmitted through the filter is affected by the quantity, size, shape and opaqueness of particulates retained on the filter. Light transmitted through the filter is measured by a photo-electric cell and the soiling index may be calculated immediately. This immediate availability of the soiling index in contrast with the time-consuming laboratory analysis required for total suspended particulate measurements has resulted in soiling index being used in the Air Pollution Index as an indicator of levels of suspended particulates.

Suspended Particulates

Two criteria for desirable ambient air quality exist for total suspended particulate matter. One is 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) averaged over a 24-hour period. The other criterion is an annual geometric mean of 60 ug/m^3. The criterion for 24-hours is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on public awareness of suspended particulates and property damage.

During 1984 filters were exposed using Hi-Vol samplers at 14 sites in the Windsor area. At all sites, except stations 12008 and 12016, samples were collected on a frequency of every-sixth-day. At station 12008 sampling was conducted every day to provide information by which it could be determined if the every-sixth-day sampling schedule is representative of the whole year. At station 12016 an every-third-day schedule was utilized. The every-third-day

schedule coincided with the sampling schedule used for the dichotomous sampler at station 12016. Sampling at station 12032 was terminated in April 1984 because the site was required for industrial development. Station 12007 was installed in July 1984 to fill the void in the sampling network created by the termination of station 12032.

With one exception the data for total suspended particulates at the various stations were very similar for 1983 and 1984. The annual criterion of 60 ug/m^3 was met at most monitoring sites while the 24-hour criterion was met or, at worst, infrequently exceeded at most sites.

The exception between 1984 and 1983 levels was the increase in levels at station 12015. The annual geometric mean concentration increased from 59 ug/m^3 in 1983 to 77 ug/m^3 in 1984. The frequency of values greater than the 24-hour criterion increased from 3 percent in 1983 to 22 percent in 1984. During 1984 emissions from local construction activities may be part of the reason for the increased levels of particulates compared to levels measured in 1982 and 1983. An evaluation of the levels of sulphates, nitrates, lead, iron and chloride in the suspended particulates at station 12015 in conjunction with information on wind speed and direction reveals that elevated levels of particulates are a result of emissions from road traffic, the local salt company, the industrialized area of Wayne County and the long-range transport of fine particulates into the Windsor area.

A summary of the data for monitoring stations in operations during 1984 is presented for the years 1972 through 1984 in Table 1. Figure 2 shows the annual geometric mean concentration and the percent frequencies of excursions above the 24-hour criterion at the approximate locations of the monitoring stations.

Table 1. Summary of data for total suspended particulates.

Station	Year												
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	Annual geometric means (ug/m^3)												
12002	159	133	108	74	76	82	79	80	77	69	62	53	50
12005							I.D.	63	55	45	45	36	38
12006												49	48
12007													(67)
12008	126	126	116	82	80	87	80	80	71	58	55	53	57
12008S											58	60	61
12009	79	82	61	52	58	54	52	57	58	46	46	36	36
12010	85	86	58	46	54	47	46	53	47	40	39	31	33
12013	151	145	113	89	98	113	100	98	75	65	68	65	66
12015	183	147	152	105	113	93	93	98	108	87	70	59	79
12016				88	88	95	84	85	83	67	63	50	54
12032	126	120	94	81	89	93	79	84	(88)	72	61	62	(60)
12036						72	63	72	70	55	53	49	49
12037						67	68	62	60	49	39	42	47
12039								79	71	71	53	49	50
	Percentage of values above 24-hour criterion												
12002	70	58	43	14	15	21	18	16	19	9	11	4	0
12005							4	4	2	2	2	0	2
12006												6	0
12007													(7)
12008	57	55	47	17	19	24	16	17	12	6	4	2	5
12008S											4	4	6
12009	16	25	10	2	5	7	9	4	9	0	4	0	0
12010	23	27	17	2	10	6	7	0	0	0	0	0	0
12013	65	69	44	26	37	40	40	42	15	5	18	16	14
12015	80	66	84	33	42	25	27	33	46	16	8	3	22
12016				20	24	22	23	20	20	6	5	3	5
12032	53	53	30	21	27	25	19	16	(20)	7	5	7	(11)
12036						11	9	15	13	2	2	0	2
12037						10	15	2	2	2	2	0	2
12039								14	8	3	6	2	0

I.D. - Insufficient data to compute a representative geometric mean.

( ) - Annual geometric mean and percentage of values above 24-hour criterion based on data not representative of total year.

Data for station 12008S are every-sixth-day sampling results extracted from the daily sampling data for station 12008.

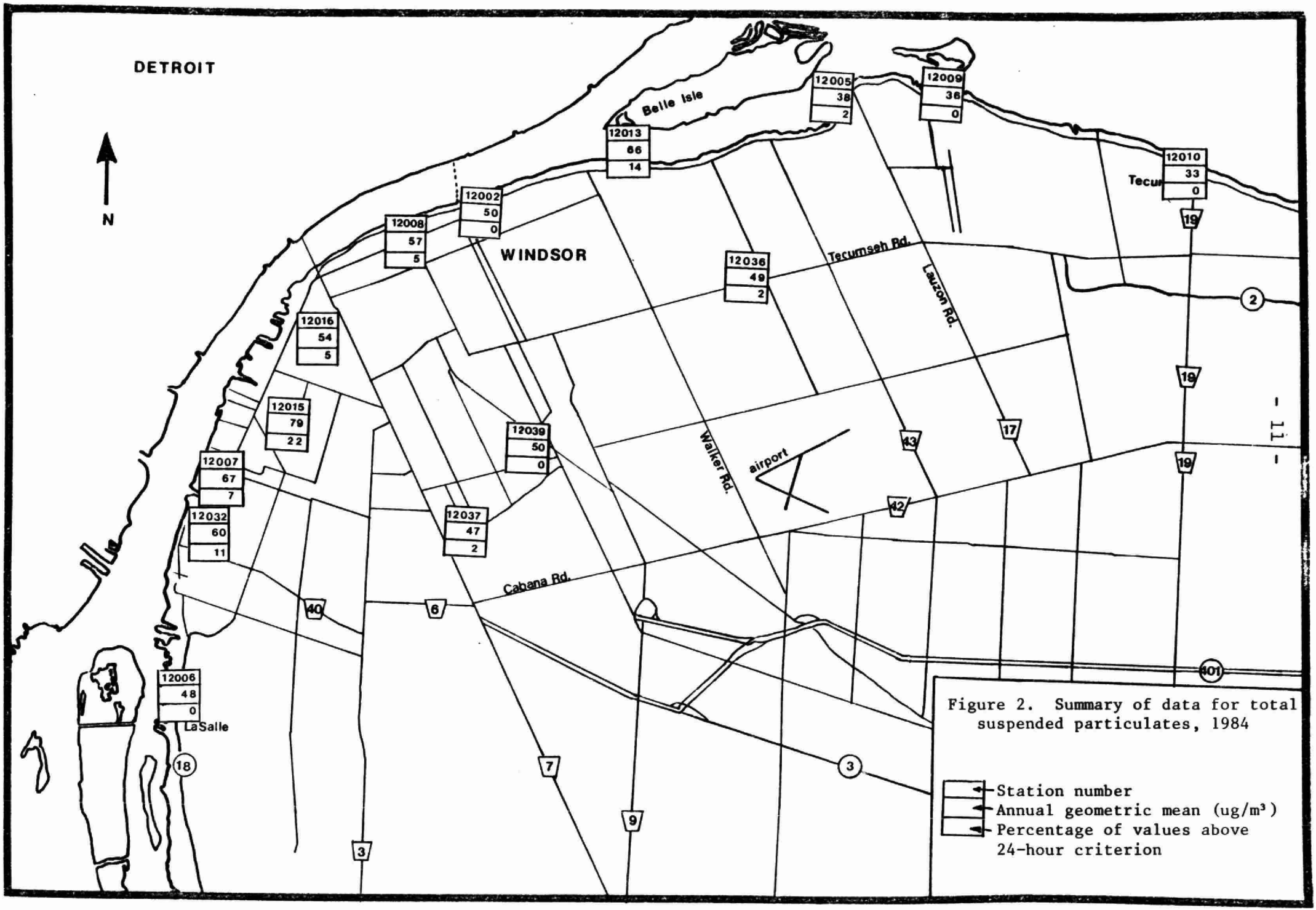


Figure 2. Summary of data for total suspended particulates, 1984

Levels of suspended particulate matter at station 12013, located near the casting plant of Ford Motor Company of Canada, Limited, were similar in 1983 and 1984. The 14 percent frequency of excursions above the 24-hour criterion for desirable ambient air quality experienced for 1984 is considered unsatisfactory and further controls have been requested.

Levels of total suspended particulate matter measured at station 12039 in 1984 met the criteria for desirable ambient air quality. During 1984 station 12039 was the closest monitoring site to the scrap metal operations of Zalev Bros.. Observations made by Ministry staff and complaints received from the public have resulted in 3 additional monitoring sites being installed in the vicinity of Zalev Bros. Measurements of iron in suspended particulate matter were elevated above background at station 12039 indicating an influence from Zalev Bros. emissions.

Figure 3 illustrates the average annual geometric mean concentrations for seven* monitoring stations in operation since 1972. Figure 4 illustrates the trend in frequencies above the 24-hour criterion for these same stations. The slight increase in average geometric means and frequencies of excursions in 1984 is attributable to the increase in levels at station 12015.

The daily sampling at station 12008 revealed that the every-sixth-day sampling schedule utilized for the other monitoring sites during 1984 would provide annual geometric means and frequencies of excursions above the 24-hour criterion that would essentially equal those that would have been obtained through daily sampling.

* Station 12032 was terminated in April 1984 and for the trend information 1984 data from stations 12007 and 12032 were combined.

Figure 3. Trend in annual levels of suspended particulates based on averaged data from seven monitoring stations.

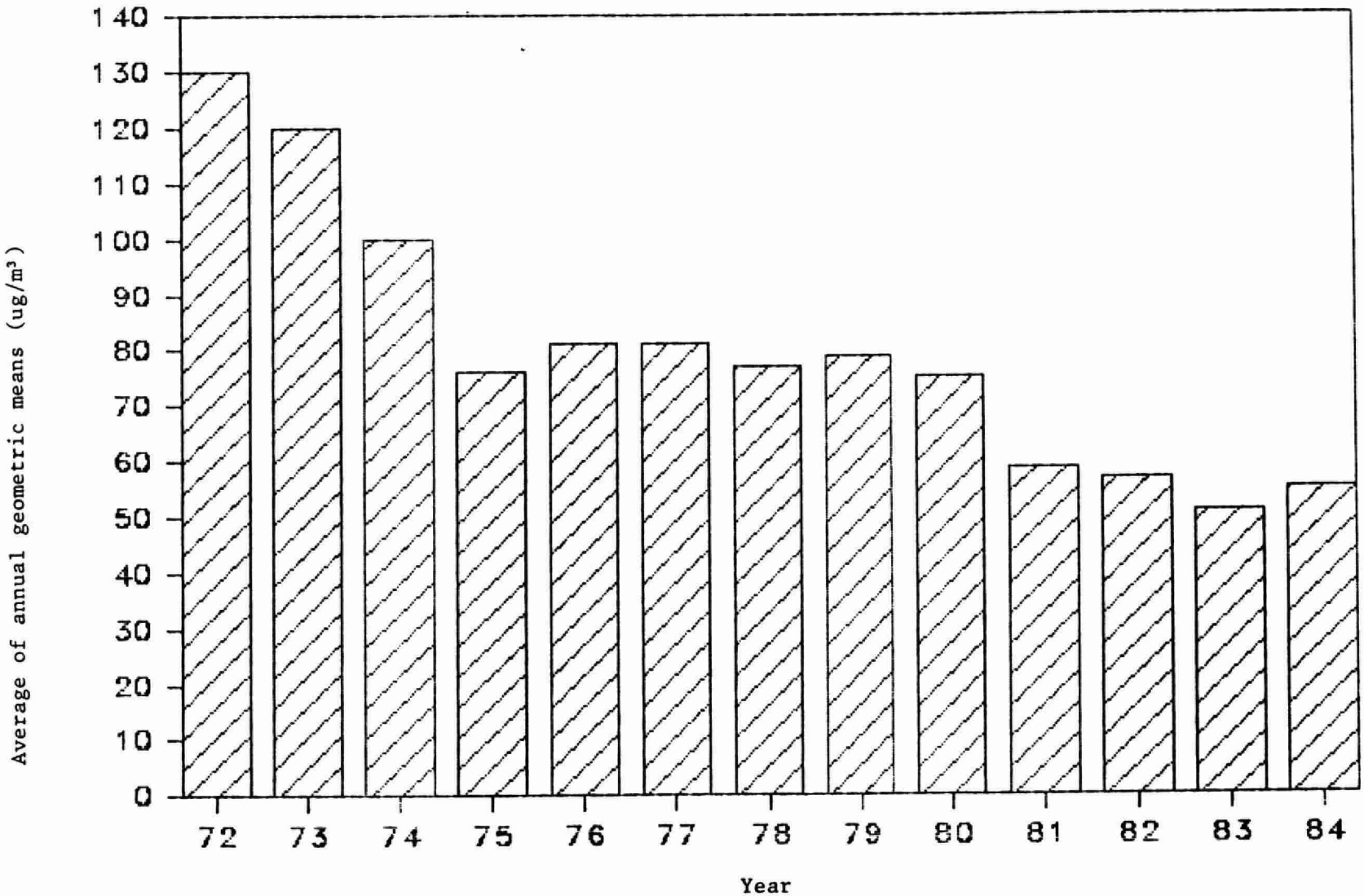
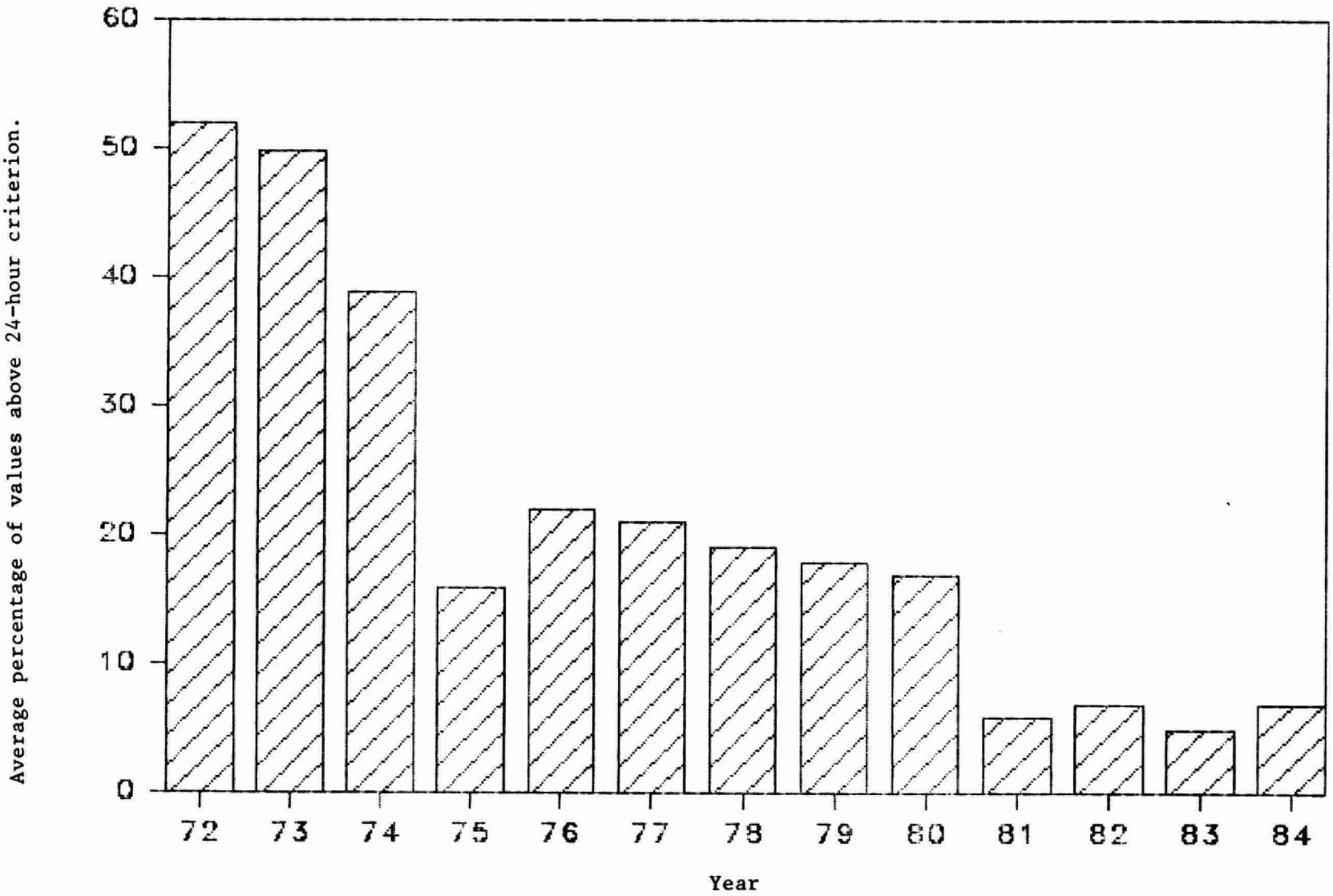


Figure 4. Trend in excursions above 24-hour criterion for total suspended particulates based on data from seven monitoring stations.



Correlations between wind direction and levels of total suspended particulates show that at most stations higher levels of total suspended particlates are generally associated with southwesterly winds.

Figure 5 provides the relative correlations at each monitoring station for 1984 data. The longer the line the higher the correlation. The higher levels associated with southwesterly winds are attributed, in part, to long-range transport of aerosols including sulphate and products of photochemical reactions. For stations in west Windsor higher levels of suspended particulates are also associated with winds from the industrialized area near Zug Island in Wayne County Michigan. The correlations for station 12032 are influenced by construction in the immediate vicinity of the station. The strong correlation for west-southwest winds at station 12013 suggests the influence of the casting plant of Ford Motor Company of Canada, Limited. At station 12039 the correlations reflect sources of suspended particulate to the east. These sources are probably the scrap metal recycling operation of Zalev Bros. Ltd. and traffic on busy roads such the E.C. Row Expressway.

Chemical Analysis of Suspended Particulates

As part of a Province-wide study, samples of suspended particulates collected at 6 stations in Windsor were analyzed quantitatively for cadmium, chromium, copper, iron, lead, manganese, nickel, nitrates, sulphates and vanadium. Also, samples from 4 additional monitoring stations were analyzed for fewer parameters. A summary of these data collected from 1976 through 1984 is presented in Appendix 2, Table A4. Data for sulphates are erroneously high based on the findings of several studies of the sampling method utilized by the Ministry. The Ministry has inves-

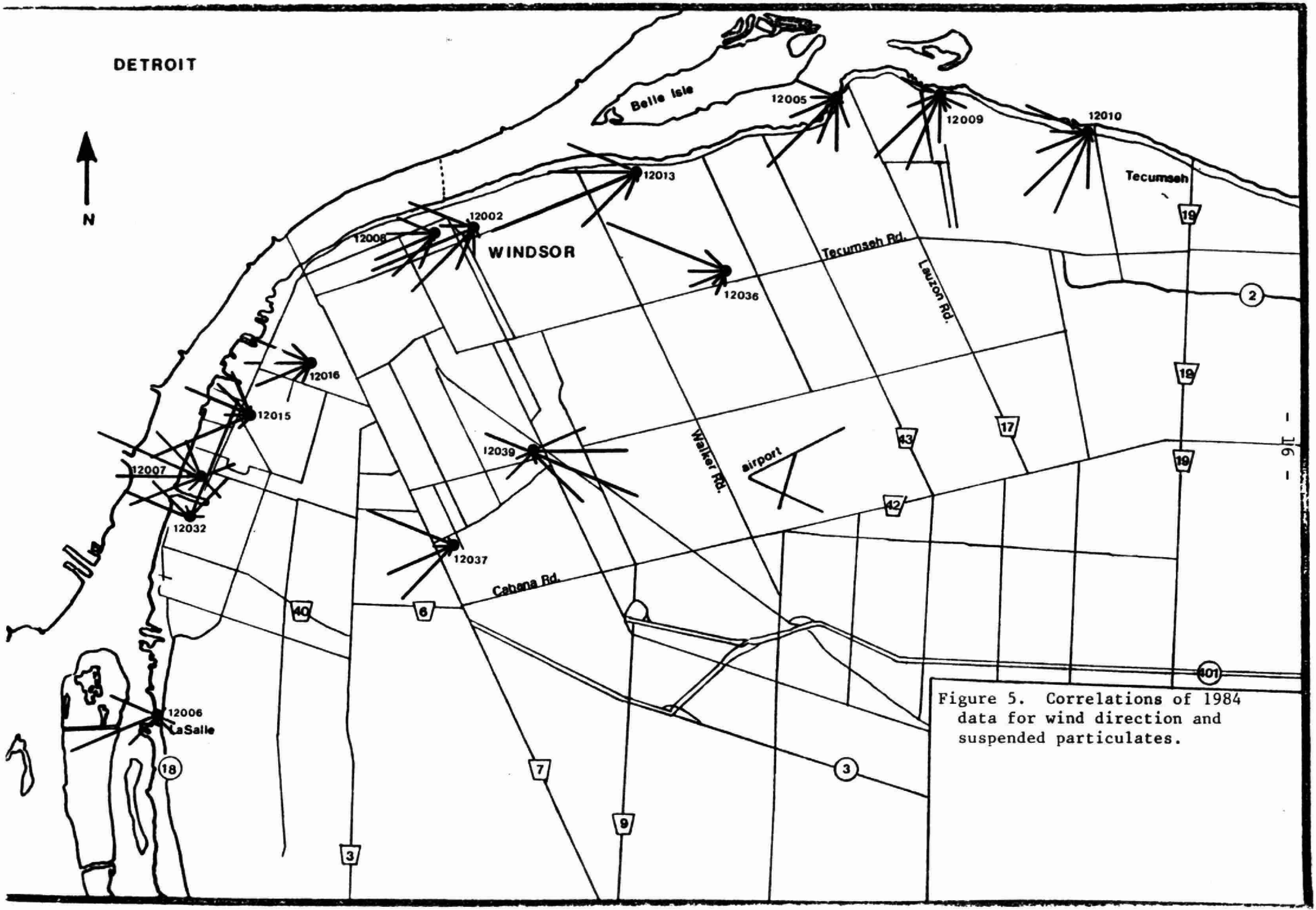


Figure 5. Correlations of 1984 data for wind direction and suspended particulates.

tigated different filter media which might provide more accurate sulphate results but have not found a filter medium that solves the sulphate problem without creating other problems. Copper results tend to be erroneously high from time to time because the vacuum pump that draws the air through the filter emits copper as a result of wear to the copper armature. These emissions can be drawn through the filter during certain meteorological conditions.

Criteria for desirable ambient air quality exist for cadmium, lead, nickel and vanadium (see Table A3). Concentrations of the various metals have been traditionally low with no values above the criteria.

Iron levels reported for station 12039 are occasionally well above background. The elevated levels occur when winds blow from the direction of the scrap metal operations of Zalev Bros. Ltd. towards the monitoring station. As was the case in 1983 the impact of emissions from Zalev Bros. Ltd. did not result in the criteria for desirable ambient air quality being exceeded at station 12039.

Station 12013 is located in the vicinity of the casting plant of Ford Motor Company of Canada, Limited. Although levels of iron and manganese are not unsatisfactory they are elevated above background at this station and reflect an impact caused by emissions from the casting plant. Furthermore, total suspended particulate levels are unsatisfactory despite extensive improvements in pollution control at the casting plant.

Chloride levels were measured in Hi-Vol samples collected at station 12015. Levels were elevated when winds were persistent from the north-northwest reflecting an impact caused by emissions from Canadian Salt Company

Limited. This station is also affected by emissions from the industrialized area of downriver Wayne County, Michigan as is reflected by the elevation in levels of iron and manganese.

Dustfall

The criteria for desirable ambient air quality established for dustfall are a 30-day loading of 7.0 grams of dustfall per square metre ($g/m^2/30$ days) and an annual average of 4.6 $g/m^2/30$ days. These criteria were established on the basis of historical data and standards developed by other regulatory agencies.

Measuring dustfall over a 30-day period is a very crude measurement subject to many interferences. As a result dustfall monitoring was phased out in southwestern Ontario with the last two sites being terminated at the end of 1984. These two sites, stations 12040 and 12046 in the La Salle area, lost appreciable data in 1984 because of interference caused by non-dustfall objects gathered in the sampler.

The amount of data available to determine the annual average dustfall loading for either station was not sufficient to be representative of the year and it is not practical to compare this data to the annual criterion. At station 12040, five valid dustfall samples were collected and none exceeded the 30-day criterion. Six valid samples were obtained at station 12046 and one exceeded the 30-day criterion.

Table 2: Levels of dustfall during 1984

Month	Dustfall Loading ($g/m^2/30$ days) Station 12040	Station 12046
January	1.5	6.5
February	3.6	2.6
March	5.6	5.4
April	5.2	5.9
May	INV	INV
June	INV	INV
July	INV	INV
August	INV	9.0
September	INV	INV
October	INV	3.3
November	INV	INV
December	3.1	INV
Annual Average	(3.8)	(5.5)

Note: INV - invalid sample
( ) - annual average based on data not representative of total year.
Underlined values exceed either the 30-day or annual criterion.

SULPHUR OXIDES

Combustion of sulphur-containing fuels comprises the predominant source of man-made emissions of sulphur oxides. The primary emitters of sulphur oxides are power generating plants and industries utilizing fossil fuels to meet requirements for large amounts of energy.

During 1984 sulphur oxides were measured in Windsor as gaseous sulphur dioxide and as sulphate in suspended particulate matter. Data for sulphate in suspended particulates are presented in Table A4 supporting the section on the Chemical Analysis of Suspended Particulates.

Sulphur Dioxide

The criteria for desirable ambient air quality with respect to sulphur dioxide are 0.25 part of sulphur dioxide per million parts of air (ppm) averaged for 1 hour, 0.10 ppm averaged for 24 hours (midnight to midnight) and 0.02 ppm as an annual average. The 1-hour and annual criteria were established for the protection of vegetation while the 24-hour criterion serves to protect human health.

During 1984 gaseous sulphur dioxide was measured by the Ministry of the Environment at seven fixed locations in Windsor. The monitoring locations are shown in Figure 1 as stations 12007, 12008, 12013, 12016, 12032, 12047 and 12048. Monitors were operated continuously throughout 1984 at stations 12008, 12013 and 12016. The monitor at station 12032 operated until April 1984 and was re-located to station 12007 where it was operated from June to the end of 1984. Monitoring stations 12047 and 12048 were operated by Ontario Hydro until March 1984 and the Ministry started continuous sulphur dioxide monitoring at these sites in April 1984.

No values above the desirable ambient air quality criteria were measured at any of the monitoring stations during 1984. A summary of the 1984 data is presented in Table 3.

In recent years levels of sulphur dioxide have been satisfactory and appreciably lower than the levels experienced in the early 1970's. The improvement is illustrated in Figures 6 and 7 which respectively show the frequencies of excursions above the 1-hour and the 24-hour criteria for sulphur dioxide as measured at station 12008 in downtown Windsor. The improved air quality is attributable to better control and dispersion of emissions of sulphur dioxide in Wayne County, Michigan and Windsor.

Figure 8 contains pollution roses for sulphur dioxide. These roses show the average sulphur dioxide concentration at 4 stations for winds blowing from specific directions. Although the criteria for desirable ambient air quality are continually met for sulphur dioxide, the pollution roses show an impact from sulphur dioxide sources in Wayne County, Michigan.

AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forecasting and readings of sulphur dioxide and suspended particulates are utilized to predict the potential for the persistence of deteriorating air quality conditions that are numerically reported as the API.

Table 3: Summary of 1984 sulphur dioxide data.

Station Number	Annual Average (ppm)	Highest 1-hr. value (ppm)	Highest 24-hr. value (ppm)	Percentage of Values greater than 1-hr criterion	Percentage of Values greater than 24-hr criterion
12007[a]	0.01	0.16	0.04	0	0
12008	0.01	0.20	0.05	0	0
12013	0.00	0.09	0.04	0	0
12016	0.01	0.15	0.04	0	0
12032[b]	0.01	0.07	0.04	0	0
12047[c]	0.01	0.15	0.03	0	0
12048[c]	0.01	0.10	0.05	0	0

(a) SO_2 measurements started in June, 1984

(b) SO_2 measured from January 1 to April 25, 1984

(c) SO_2 measurements by the Ministry were initiated in April, 1984

Figure 6. Trend in excursions above 1-hour criterion for sulphur dioxide at station 12008.

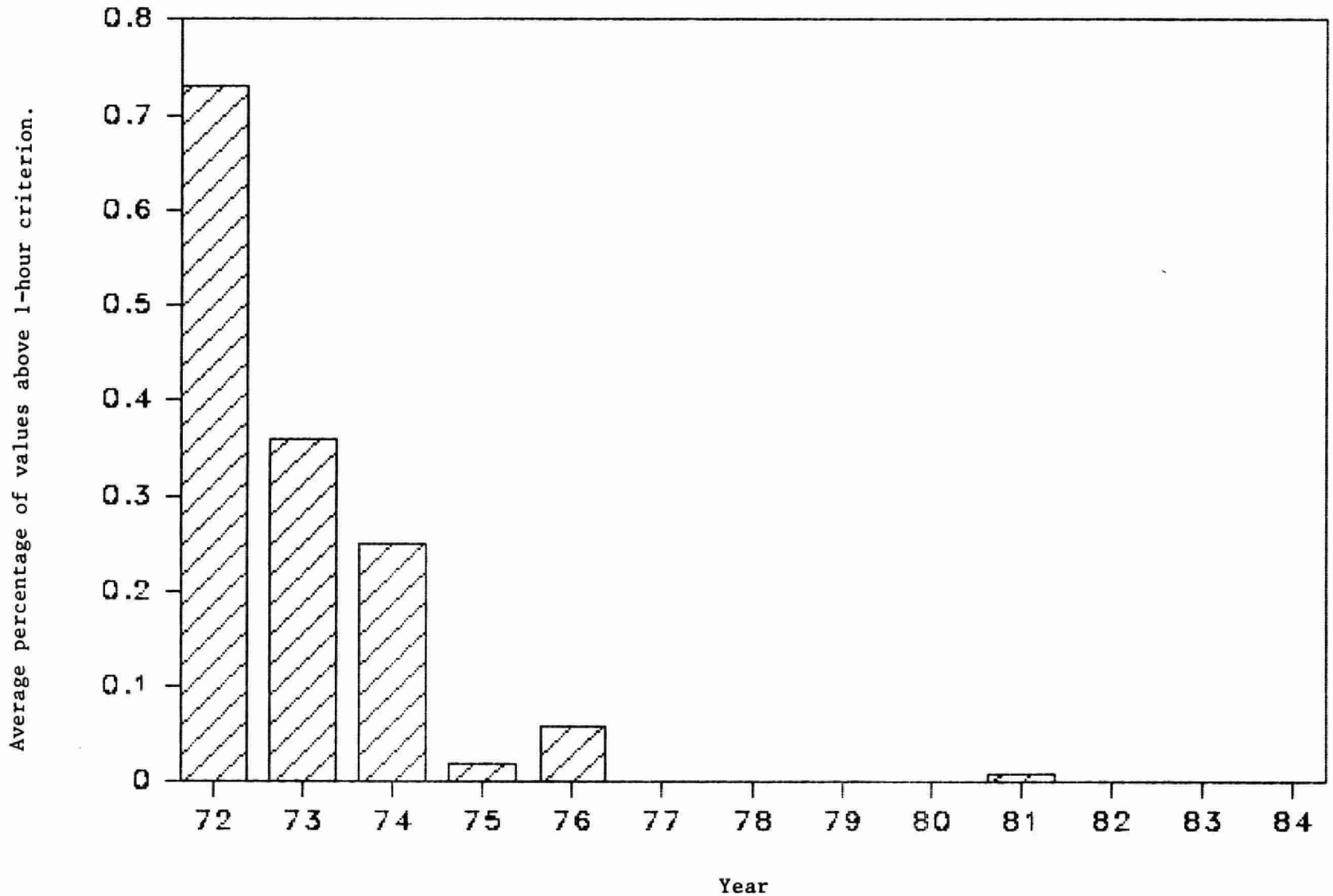
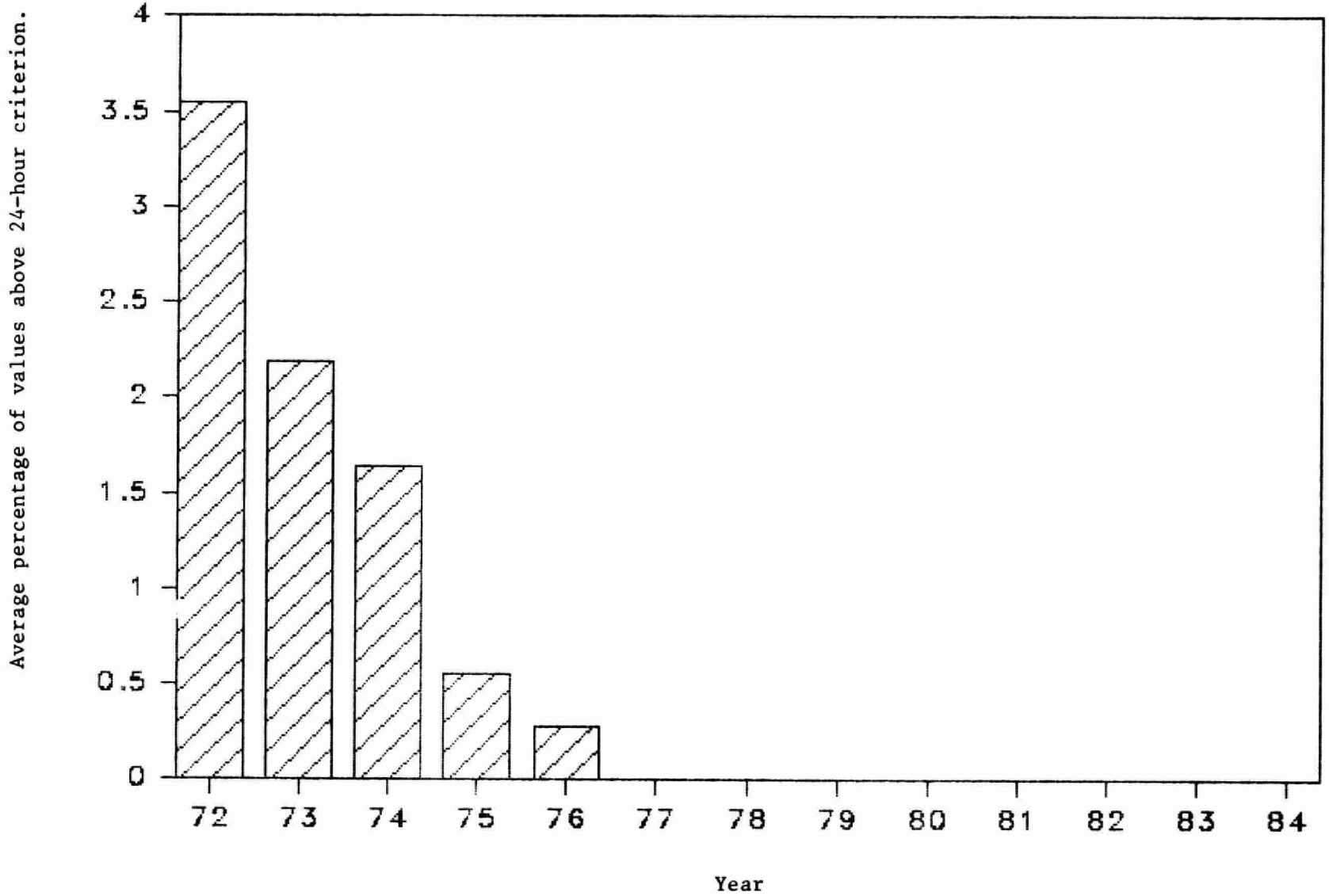


Figure 7. Trend in excursions above 24-hour criterion for sulphur dioxide at station 12008.



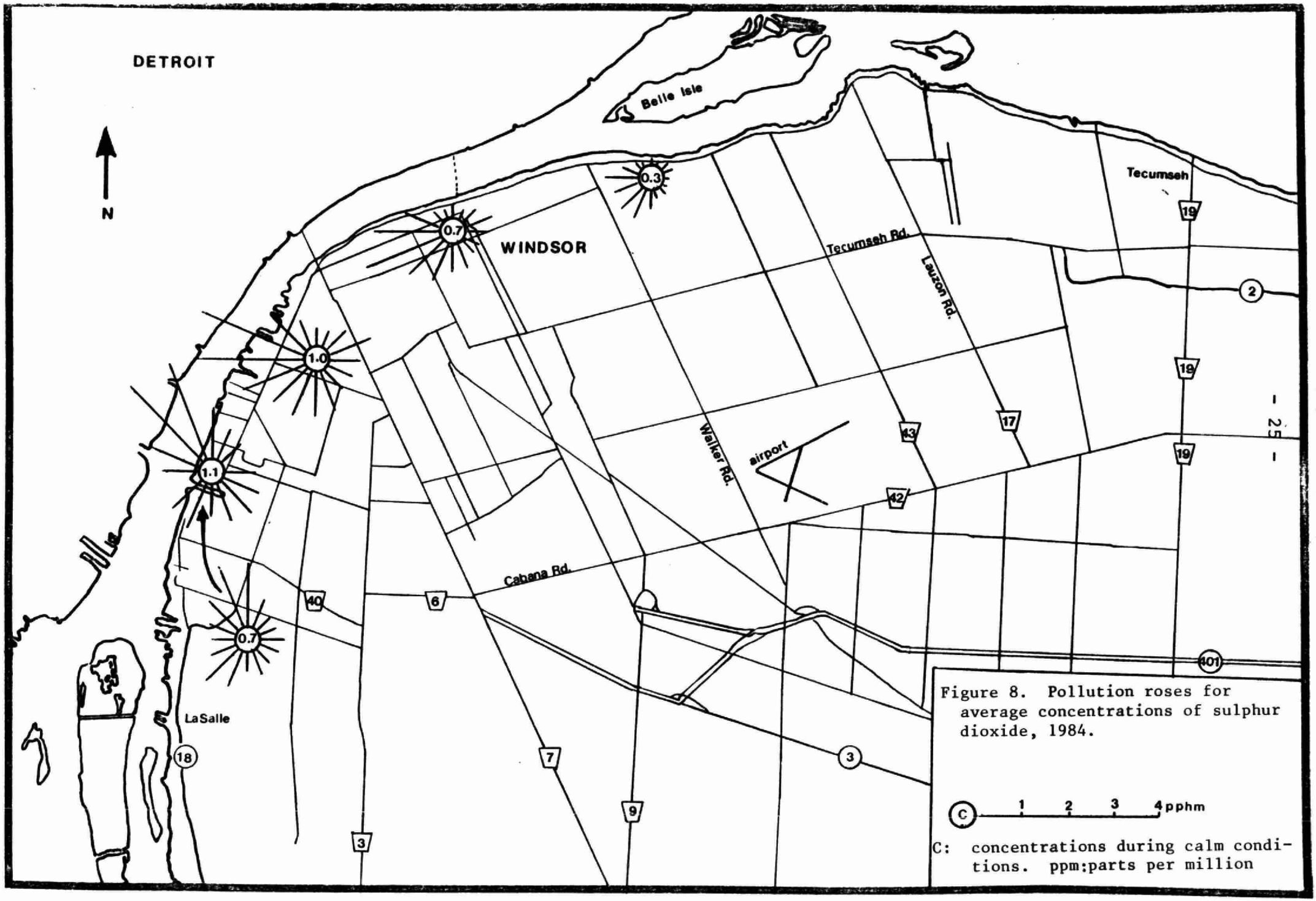


Figure 8. Pollution roses for average concentrations of sulphur dioxide, 1984.

C: concentrations during calm conditions. ppm:parts per million

Data for suspended particulates are provided by the measurement of soiling index and a correlation between concentrations of suspended particulates and soiling index. Hourly values of soiling index and gaseous sulphur dioxide are used to compute 24-hour running averages which are inserted into the following equation:

$$API = 0.78\ (18.26\ COH + 156.7\ SO_2)^{1.06}$$

where: COH is the 24-hour average for soiling index expressed in co-efficient of haze units

and

SO_2 is the 24-hour average concentration of sulphur dioxide expressed in parts per million.

API values up to 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, major emitters are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. If the API reaches 100 all industries and other pollution generating activities not essential to public health and safety can be ordered to cease operation.

Levels of soiling index and sulphur dioxide utilized for the computation of the API are obtained at stations 12008 in downtown Windsor, and at station 12016 in west Windsor. At station 12008 the API did not reach the Advisory Level of 32. On February 15, 1984 the API reached the Advisory Level at station 12016 and for 19 consecutive hours was above 32 with the maximum value being 40. The rest of the readings for 1984 were below the Advisory Level.

The API levels above 32 were attributable almost entirely to elevated levels of particulates as sulphur dioxide levels were low.

TOTAL REDUCED SULPHUR

Gaseous total reduced sulphur compounds often exhibit malodours at very low concentrations. Hydrogen sulphide is a reduced sulphur compound commonly referred to as rotten egg gas. Mercaptans are also reduced sulphur compounds. There are many sources of reduced sulphur compounds including natural decomposition of organic material. In west Windsor there are occasional malodours which may be caused by reduced sulphur compounds. Probable sources of these odours are the coking operations of the steel industry in Wayne County, Michigan. There is also suspicion that some of the malodours experienced around the casting plant of Ford Motor Company of Canada, Limited may be caused by reduced sulphur compounds.

The Ministry of the Environment has a desirable ambient air quality criterion for mercaptans of 10 parts per billion (ppb) during a 1-hour period. There is also a criterion for hydrogen sulphide which is 20 ppb during a 1-hour period. These criteria were established on the basis of odour. Unfortunately the instrument used by the Ministry to measure total reduced sulphur compounds does not differentiate between hydrogen sulphide and mercaptans. The instrument reports the combined levels of hydrogen sulphide and mercaptans as total reduced sulphur, expressed as hydrogen sulphide. In consideration of the combined levels measured by the instrument, the levels are compared with the less restrictive criterion for hydrogen sulphide.

From January to April 1984 monitoring for total reduced sulphur was conducted at station 12032 in west Windsor. The monitor was relocated to station 12007, also in west Windsor and was operated from July through to the end of 1984. In April 1984 a total reduced sulphur monitor was installed at station 12013, near the casting plant of Ford Motor Company of Canada, Limited. The 20 ppb criterion was exceeded at both stations 12007 and 12032 in west Windsor and not exceeded at station 12013. Table A5, in Appendix 3, contains a summary of the data.

The pollution roses for total reduced sulphur as shown in Figure 9 reveal appreciably higher levels of total reduced sulphur compounds when winds are blowing from the industrialized area in Wayne County, Michigan than when winds are from other directions. There is an indication that total reduced levels at station 12013 may be increased when winds are blowing from the direction of the casting plant of Ford Motor Company of Canada, Limited. However the impact was not large enough to cause any excursions above the desirable criterion.

The differences in the annual average concentrations for the various monitoring stations are not considered significant since the vast majority of total reduced sulphur measurements are at or near the detection limit of the monitoring instrument.

CARBON MONOXIDE

Combustion processes account for man's major emissions of carbon monoxide. Emissions from motor vehicles are especially significant because they are near ground level and are concentrated in urban areas where the public may be exposed for long periods. Major industries and power generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in ambient air.

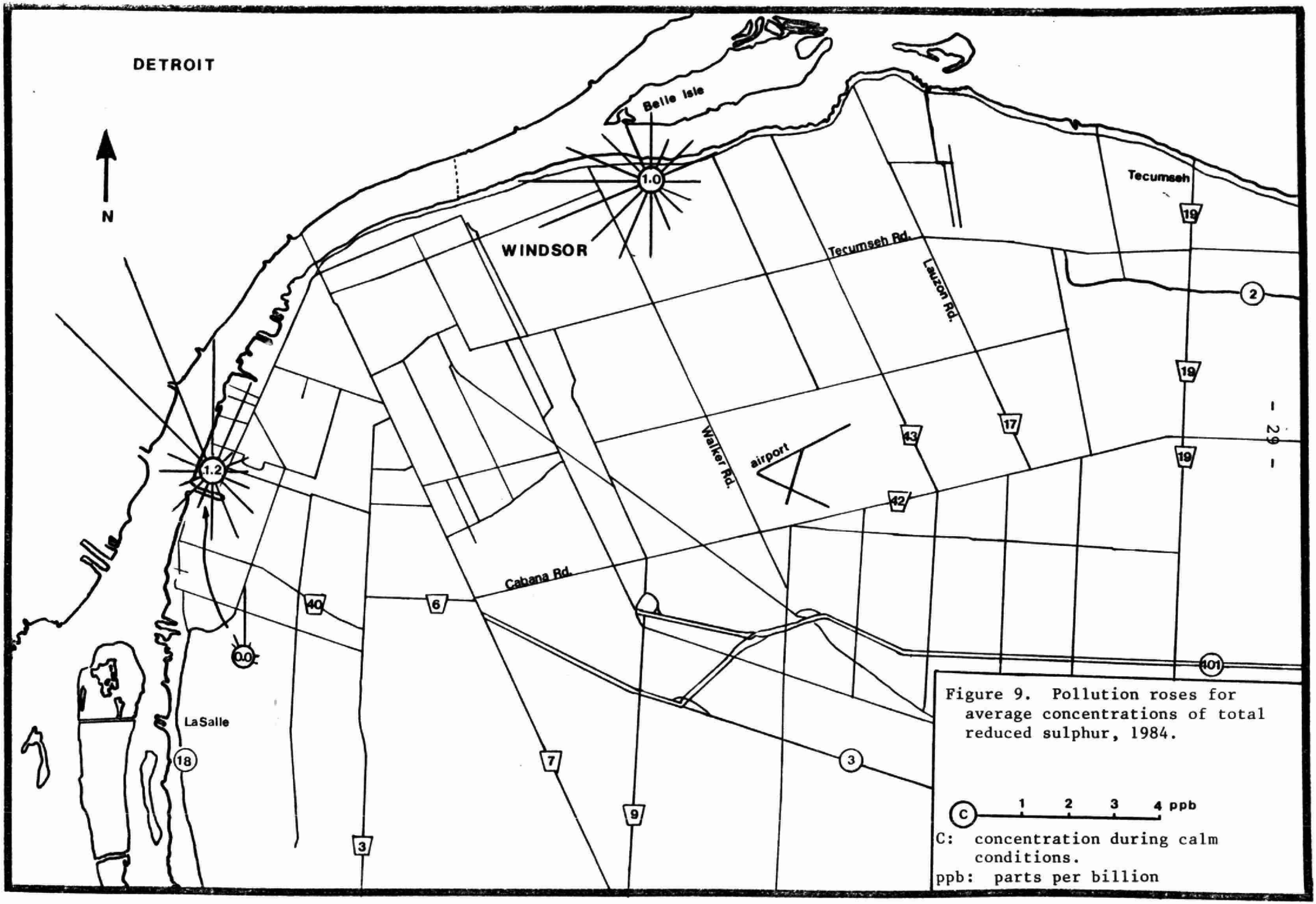


Figure 9. Pollution roses for average concentrations of total reduced sulphur, 1984.

C 1 2 3 4 ppb

C: concentration during calm conditions.

ppb: parts per billion

The criteria for carbon monoxide are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8 hours. These criteria were established for the protection of human health and have not been exceeded in the past 9 years, based on monitoring at station 12008. Since this station is located in the downtown area of Windsor where the highest levels of carbon monoxide are anticipated, there is a high probability that levels are acceptable throughout the Windsor area.

A summary of data for carbon monoxide, obtained since 1972, is presented in Appendix 3, Table A5. Data obtained from 1972 to 1976 are higher than data for the past 8 years. The differences in measured levels are attributed in part to replacement in late 1976 of a less accurate monitoring instrument with a more sophisticated one.

OXIDES OF NITROGEN

Like many other pollutants, oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria for nitrogen dioxide, which are based on the protection of human health and offensive odours, are 0.20 ppm averaged for 1 hour and 0.10 ppm average for 24 hours (midnight to midnight).

During 1984 the criteria were not exceeded. The 24-hour criterion has not been exceeded at station 12008, located in downtown Windsor, since the chemiluminescence-type monitor was installed in 1974. During the same time period there has been only one excursion above the 1-hour

criterion. Since emissions from motor vehicles are concentrated in the downtown area, levels of oxides of nitrogen would probably be higher at station 12008 than in other areas of Windsor. A summary of the data for oxides of nitrogen is presented in Table A5, Appendix 3.

Although levels of nitrogen dioxide have been very favourable when compared to the criteria, there is concern about oxides of nitrogen because of acidic precipitation and their role in the formation of unsatisfactory levels of photochemical oxidants. Consequently, more stringent controls for oxides of nitrogen are under consideration.

HYDROCARBONS

The principal man-made sources of hydrocarbons are emissions from landfill sites and motor vehicles. Other significant man-made sources are incomplete combustion of fuels by industries and power generating plants and evaporation losses during manufacture, use, storage and transportation of materials containing volatile hydrocarbons. In the Windsor area, hydrocarbon emissions from distilleries and distillery warehouses account for a large proportion of emissions from stationary sources. Also emissions from motor vehicle painting are significant in the Windsor area. Natural phenomena produce many hydrocarbon of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable ambient air quality have been established for total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Although there are no criteria for total hydrocarbons, monitoring for them provides information on trends in levels of hydrocarbons. Increasing levels of hydrocarbons could be significant should they be attributable to detrimental compounds. Furthermore, the non-methane or "reactive"-hydrocarbons may partake in photochemical reactions which produce excessive levels of oxidants.

Total hydrocarbons, methane and non-methane hydrocarbons are monitored continuously at station 12008 in downtown Windsor using flame ionization detection. Continuous monitoring for other specific hydrocarbons is not done. However, when problems are suspected special monitoring surveys are conducted for specific hydrocarbons. These surveys are often very complicated and difficult and often must be repeated several times to properly identify and quantify specific hydrocarbons. In 1984 special studies using mobile monitoring vans were conducted in the environs of the Chrysler plant and the Ford casting plant. The results of these surveys are available through the Windsor District Office.

Levels of total hydrocarbons and reactive hydrocarbons at station 12008 have been very similar in recent years with no trend of changing levels apparent. A summary of annual average concentrations appears in Table A5, Appendix 3.

OXIDANTS

A major portion of the oxidants in ambient air are a result of photochemical reactions and inter-reactions involving oxides of nitrogen and reactive hydrocarbons. The reactions are promoted by certain meteorological conditions such as warm temperatures and intense sunshine. Consequently, higher levels of oxidants are experienced in the spring and summer months.

Ozone normally accounts for 80 to 90 percent of the photochemical oxidants in ambient air. The monitoring technology for ozone is more accurate and efficient than that for total oxidants. For these reasons, most regulatory agencies, including this Ministry, monitor for ozone rather than total oxidants.

Ozone is also present in the stratosphere where it plays the critical role of absorbing ultraviolet radiation that in excessive amounts may be biologically harmful. Occasionally ozone from the stratosphere may be transported downwards to cause elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

Long-range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) can account for a very significant portion of local levels of ozone. Incidents of long-range transport from distances greater than 200 kilometres have been reported in the literature. Consequently, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario.

The Environmental Protection Agency (EPA) in the United States has established a primary standard for ozone of 0.12 ppm averaged for 1 hour. Individual states are required to bring ozone levels into compliance with the standard by the end of 1987.

The Ontario criterion for desirable ambient air quality is 0.08 ppm averaged for 1 hour. This criterion was established for the protection of vegetation, property and human health. Some effects detrimental to health that are associated with oxidants are eye irritation and a decrease in performance during physical activities. Oxidant damage to crops in Ontario is estimated at millions of dollars

annually. Ontario has established a special section in its Long-Range Transport of Air Pollutants program to study the oxidant situation and to develop a suitable control strategy.

Ozone is monitored by a chemiluminescence-type instrument at station 12008, in downtown Windsor. During 1984 there were 139 hourly values reported in excess of the 1-hour criterion, all of which occurred during the months of June through September. With photochemical formation of ozone being dependent on meteorological conditions, there may be large fluctuations from year to year in the frequency of excursions above the criterion. A summary of ozone data, presented in Appendix 3, Table A5, shows that the frequency of excursions above the criterion was the greatest since 1980.

A pollution rose, showing the frequency of ozone values above the 1-hour criterion in relation to wind direction, appears in Figure 10. The vast majority of the excursions are associated with winds from the southwest and south-southwest. Most of the excursions associated with these wind directions are a result of long-range transport of ozone and its precursors. The abatement strategies being developed in the United States should reduce the number and magnitude of excursions attributable to long-range transport.

FLUORIDES

Sources of fluorides in the Windsor area are the steel industry located in the downriver area of Wayne

County, Michigan, power generating plants where coal burned contains trace amounts of fluorides, fluorspar unloading operations at docks in west Windsor and subsequent trucking of fluorspar to a location south of Windsor.

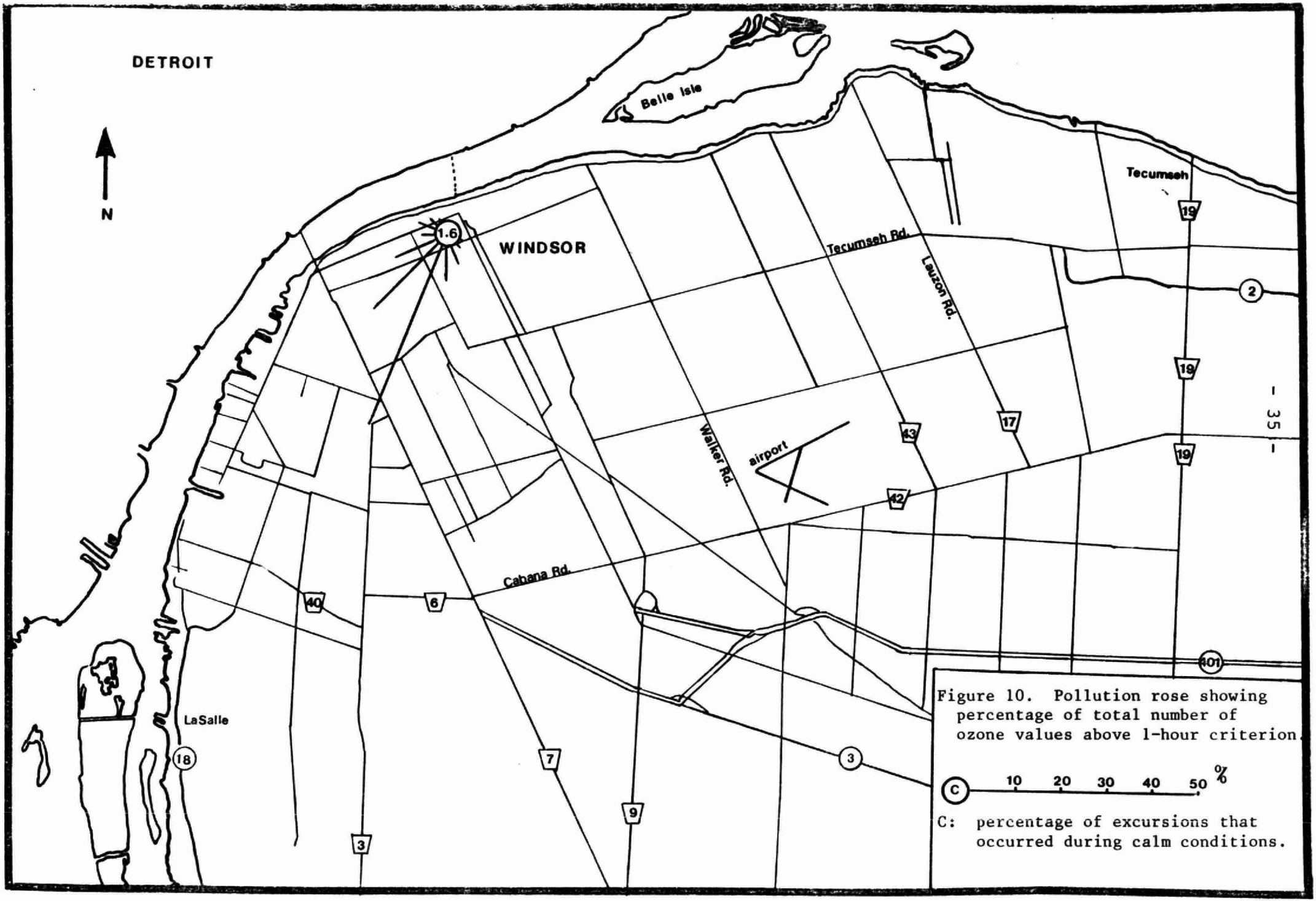


Figure 10. Pollution rose showing percentage of total number of ozone values above 1-hour criterion.

C: percentage of excursions that occurred during calm conditions.

Fluoridation rate is a measurement designed to indicate the relative amounts of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and then analyzed for fluoride content. This monitoring technique measures primarily gaseous fluoride but some fluoride in particulate form may be collected on the filter.

The criteria for desirable ambient air quality established for fluoridation rate are based on the protection of vegetation. Consequently, a criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ug F/100 cm^2/30 days) has been established for the growing season from April 15 to October 15 while a criterion of 80 ug F/100 cm^2/30 days applies for the period of October 16 to April 14. Since the months of April and October are common to both criteria and fluoridation rate is measured on a monthly basis, excursions during these months are determined by comparing the fluoridation rate to the average of the two criteria (60 ug F/100 cm^2/30 days). In recent years, investigations of vegetation have not revealed any appreciable damage to vegetation in Windsor attributable to fluorides.

During 1984 there were eight sites where fluoridation rates were monitored, 5 in west Windsor and 3 in the downtown area. Fluoridation rate was measured at station 12032 until the end of April, 1984 and measurements commenced in August, 1984 at station 12007. The growing season criterion was exceeded once at stations 12015, 12016 and 12022. The criterion for the non-growing season was exceeded once at station 12015. Figure 11 shows that again in 1984 fluoridation rates were higher in west Windsor than in La Salle or the downtown area. The 1984 fluoridation rates appear in Table 4.

Fluoridation rate is not considered a sensitive indicator to temporal trends of fluoride levels. However based on data from six monitoring sites in operation since 1972*, the annual average of fluoridation rate and the frequencies of excursions above the criteria for desirable ambient air quality have been lower in recent years with the lowest values being experienced from 1982 to 1984. Figures 12 and 13 show the trend towards lower levels of fluoridation rates.

* Data for station 12032 in 1984 were combined with data for station 12007 which is situated near station 12032. This was done to obtain data representative of the period after the termination of station 12032 at the end of April 1984.

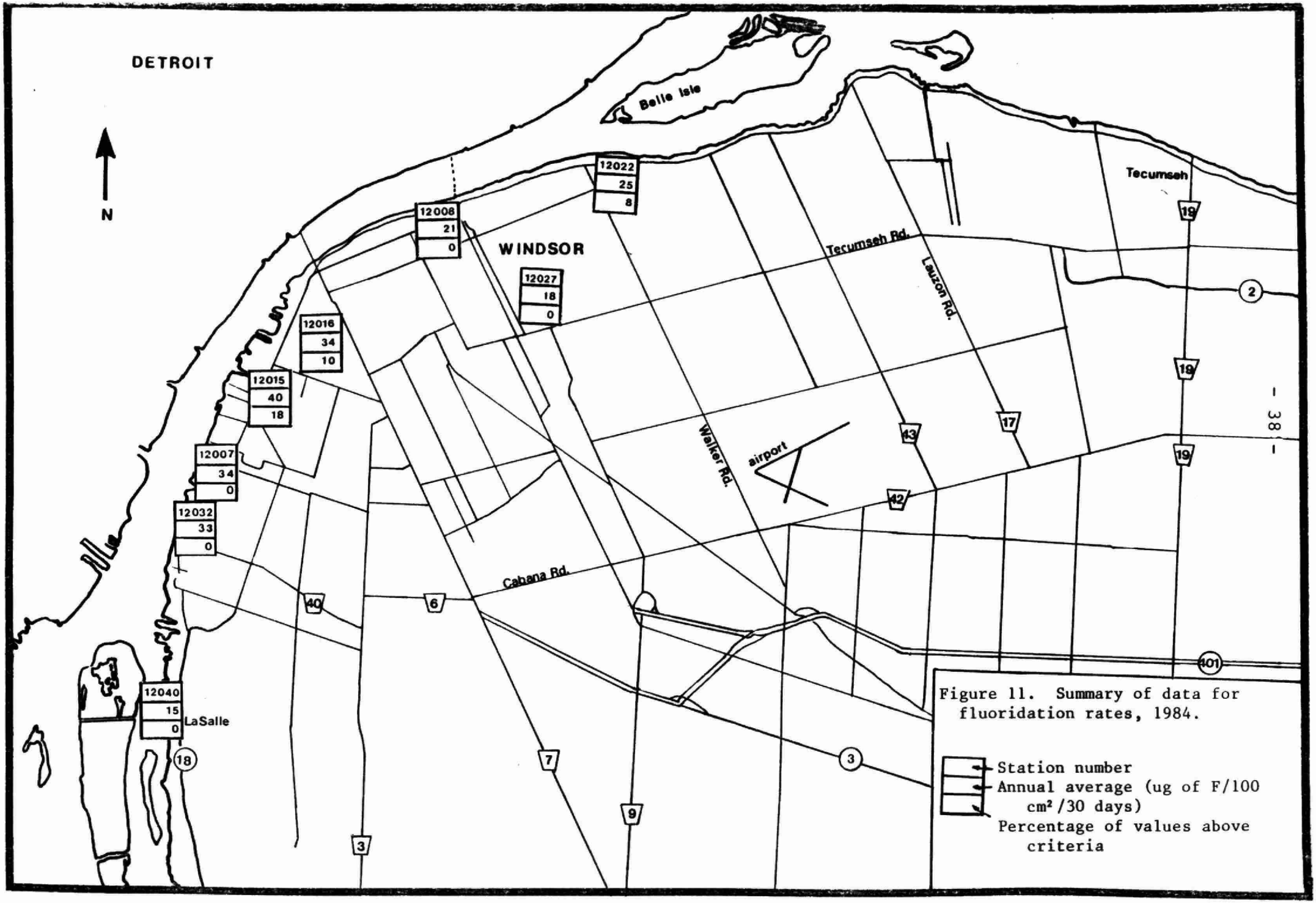


Figure 11. Summary of data for fluoridation rates, 1984.

Station number
Annual average (ug of F/100 cm^2/30 days)
Percentage of values above criteria

Table 4. Levels of fluoridation rate during 1984

Station Number	Fluoridation rate (ugF/100 cm^2/30 days) Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Average	Percentage of values above criteria
12007								17	38	35	40	42	34	0
12008	18	24	18	7	25	34	26	11	15	26	20	33	21	0
12015	43	52	21	23	<u>45</u>		38	22	29	36	<u>87</u>	46	40	18
12016	37	32	32	18	32	<u>46</u>	25			8	66	40	34	10
12022	20	23	19	17	27	25	26	<u>61</u>	17	22	21	21	25	8
12027	20	18	4	12	26	22	26	6	18	21	24	21	18	0
12032	42	51	25	13									33	0
12040	17	18	8	12	18	21	14	6	17	19	14	19	15	0

Note: Underlined values exceed criteria for desirable ambient air quality

Figure 12. Trend in annual levels of fluoridation rate based on averaged data for six monitoring stations.

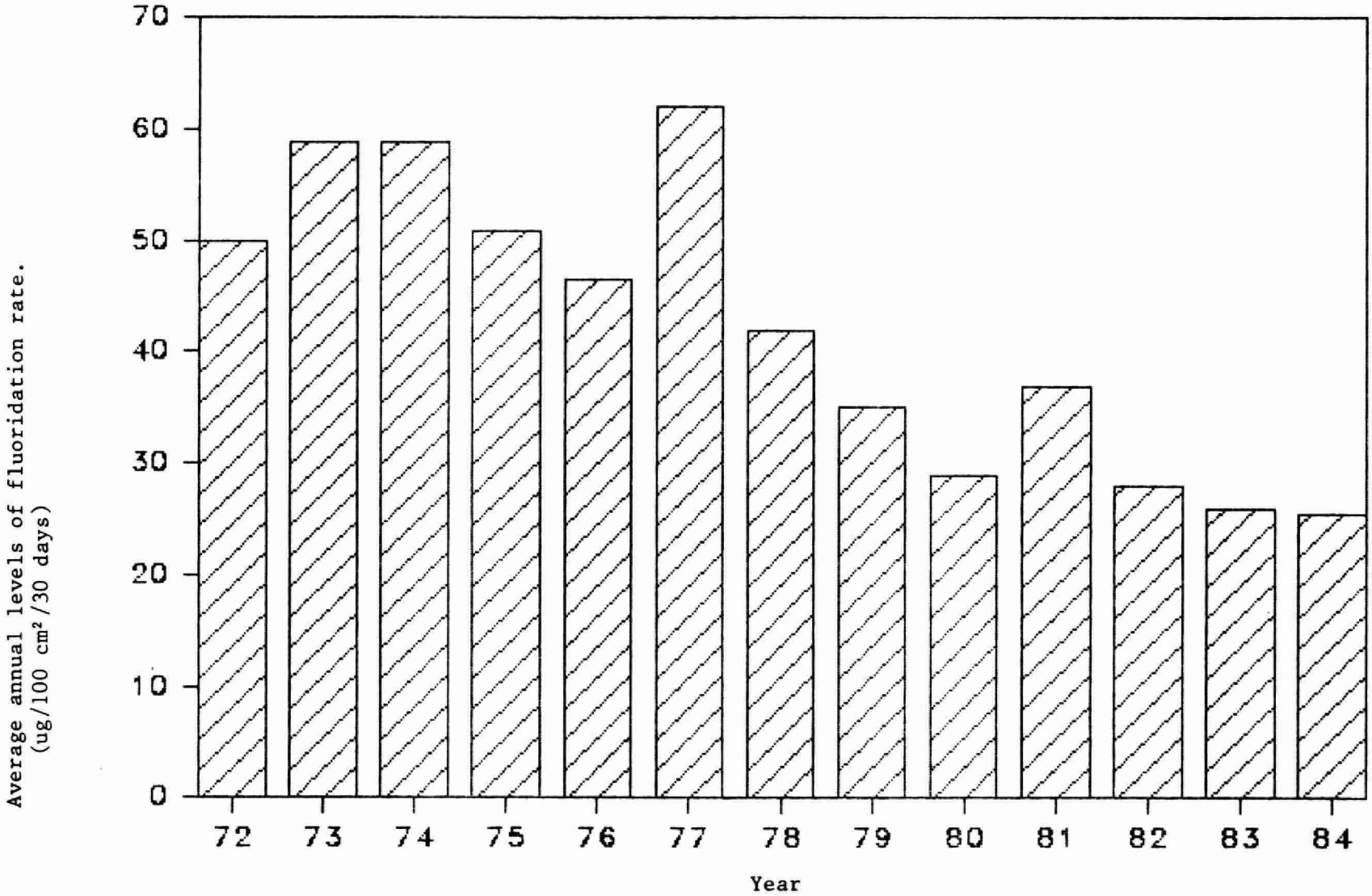
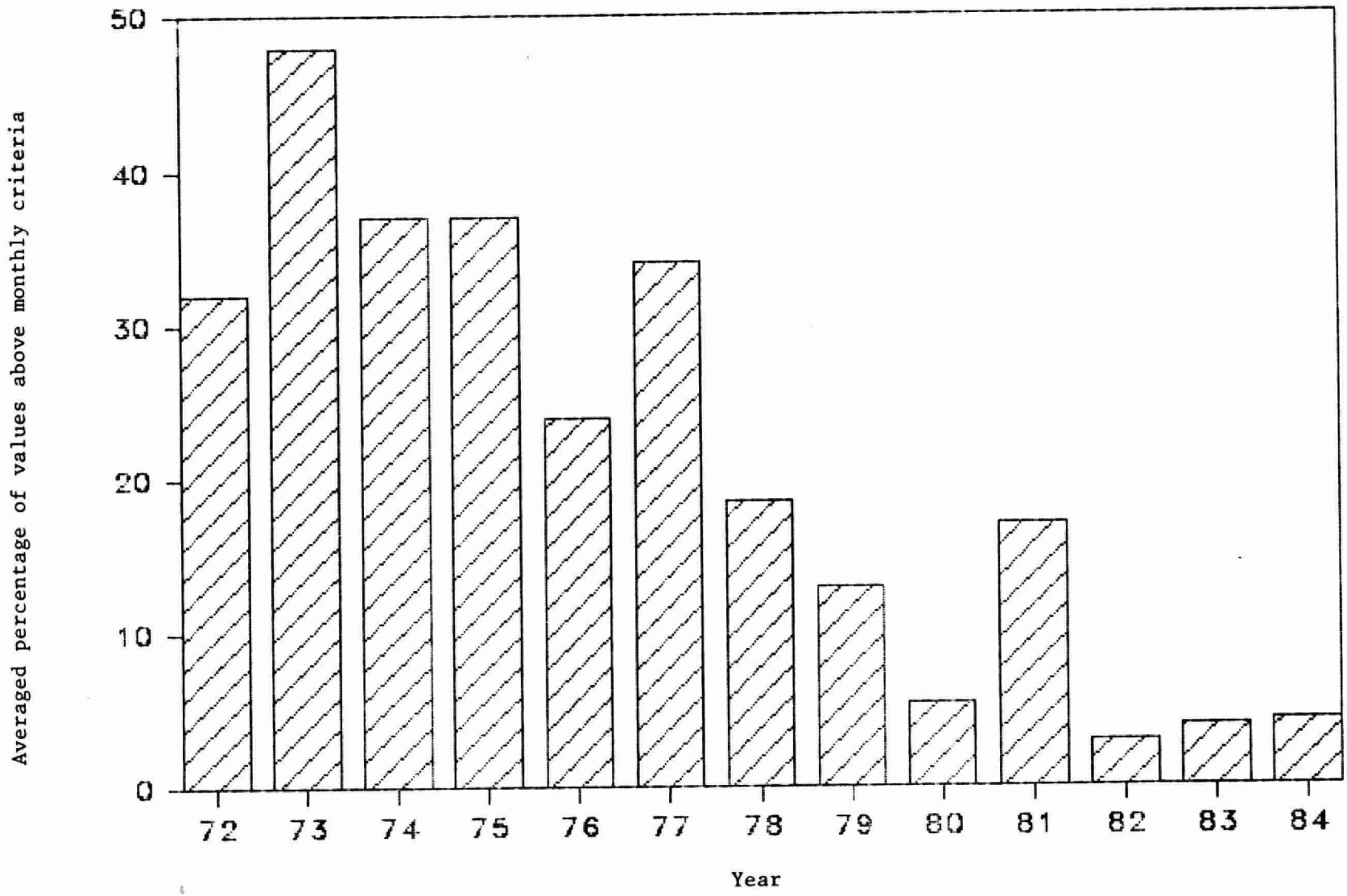


Figure 13. Trend in excursions above monthly criteria for fluoridation rate based on averaged data for six monitoring stations.



APPENDIX 1

DESCRIPTION OF MONITORING NETWORK

Table A1. Locations of air monitoring stations

Station number	Location	Universal transverse mercator projection co-ordinates	Elevation above sea level (metres)	Air intake height (metres)
12001	1.1 km NNE of J. C. Keith Generating Station	03276 - 46839	180	80
12002	444 Windsor Avenue, City Hall	03323 - 46867	183	17
12005	7730 Riverside Drive East	03395 - 46890	177	10
12006	Beach Lane/Hwy. 18 (LaSalle)	03264 - 46778	176	4
12007	Wright St./Water St.	03271 - 46823	177	4
12008	467 University Avenue	03316 - 46867	183	12
12009	Tecumseh Water Works	03413 - 46888	180	2
12010	Tecumseh Sewage Pumping Station	03460 - 46875	181	1
12013	3665 Wyandotte Street East	03358 - 46874	185	7 & 10
12015	Highway No. 18/Prospect	03283 - 46833	175	6
12016	College/South Street	03290 - 46841	175	4
12022	Hickory/Richmond Street	03352 - 46870	183	5
12027	1526 Parent Street	03340 - 46852	183	5
12032	Morton Dock	03271 - 46817	175	4
12036	1794 Westcott Street at Milloy Street	03367 - 46858	186	5
12037	3225 California Street (St. Hubert's School)	03327 - 46816	183	4
12039	Dougall St./E. C. Row W	03337 - 46821	195	5
12040	225 Willow Drive (La Salle)	03261 - 46773	175	5
12046	Adams/Hwy 18	03264 - 46778	175	5
12047	Dorwin Plaza, Dougall Ave.	03327 - 46834	187	3
12048	Malden Rd./Laurier Ave.	03299 - 46766	178	3

Table A2. Parameters monitored in the ambient air in Windsor during 1984

Station Number	Air Pollution Index	Carbon Monoxide	Dustfall	Fluoridation Rate	Hydrocarbons	Meteorological Data	Nitric Oxide	Nitrogen Dioxide	Nitrogen Oxides	Ozone	Soiling Index (1-hr COH)	Sulphur Dioxide	Suspended Particulates	Total Reduced Sulphur
12001						X								
12002													X	
12005													X	
12006													X	
12007				X								X	X	X
12008	X	X		X	X		X	X	X	X	X	X	X	
12009													X	
12010													X	
12013												X	X	X
12015				X									X	
12016	X			X							X	X	X	
12022				X										
12027				X										
12032				X								X	X	X
12036													X	
12037													X	
12039													X	
12040			X	X										
12046			X											
12047												X		
12048												X		

Table A3. Desirable ambient air quality criteria established by the Ontario Ministry of the Environment

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour 13 ppm averaged for 8 hours	Protection of human health Protection of human health
Dustfall	7 grams/metre^2 in 30 days 4.6 grams/metre^2 (monthly average in 1 year)	Historial and in keeping with other control agencies
Fluoridation rate	40 ug of fluorides/100 cm^2 of limed filter paper in 30 days during April 15 to October 15	Protection of vegetation
	80 ug of fluorides/100 cm^2 of limed filter paper in 30 days during October 16 to April 14	Protection of vegetation (less restrictive criterion during the non-growing season)
Hydrocarbons (total)	None	Effects of hydrocarbons vary widely depending on their chemical-physical nature
Hydrogen Sulphide	0.02 ppm averaged for 1 hour	Protection against offensive odours
Mercaptans	0.01 ppm averaged for 1 hour	Protection against offensive odours
Nitric oxide	None	Reacts with oxygen to produced NO_2
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against odours
	0.10 ppm averaged for 24 hours	Protection of human health and protection against odours
Oxides of nitrogen	None	

Table A3. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation, property and human health
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m^3 averaged for 24 hours	Based on impairment of visibility and health effects
	60 ug/m^3 (geometric mean) during 1 year	Based on public awareness of visible pollution
Cadmium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health
Lead in suspended particulates	5.0 ug/m^3 averaged for 24 hours	Based on protection of human health
	2.0 ug/m^3 as a geometric mean over a 30 day period	Based on protection of human health
Nickel in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of vegetation
Vanadium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health

APPENDIX 2

PARTICULATES

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12002															
1976	12	0.003	0.010	12	0.007	0.022	12	0.11	0.36	12	3.4	8.2	12	0.7	1.1
1977	20	0.006	0.016	20	0.032	0.062	20	0.16	0.52	20	3.1	8.4	20	0.7	1.3
1978	24	0.007	0.035	24	0.018	0.045	24	0.23	0.62	24	3.1	9.9	56	0.7	1.5
1979	28	0.004	0.020	28	0.009	0.026	28	0.08	0.20	27	2.0	5.9	49	0.5	1.0
1980	23	0.002	0.008	23	0.006	0.015	23	0.06	0.16	23	1.5	3.2	51	0.4	2.1
1981	55	0.003	0.024	55	0.006	0.027	55	0.03	0.20	55	1.8	6.9	58	0.3	2.0
1982	51	0.003	0.014	51	0.007	0.090	51	0.05	0.15	49	1.4	4.2	54	0.3	1.0
1983	33	0.002	0.009	33	0.004	0.016	33	0.06	0.10	33	1.3	3.0	49	0.3	0.9
1984	34	0.002	0.012	34	0.004	0.009	34	0.05	0.10	34	1.4	3.9	57	0.1	0.6
12005															
1981	59	0.003	0.035	59	0.004	0.030	58	0.05	0.27	59	1.2	13.0	59	0.3	2.6
1982	54	0.005	0.022	53	0.006	0.043	54	0.06	0.67	49	0.7	2.7	54	0.2	1.1
1983	52	0.002	0.010	48	0.002	0.011	52	0.08	0.29	52	0.8	2.5	51	0.2	0.6
1984	53	0.001	0.005	53	0.004	0.034	53	0.02	0.09	53	0.8	2.5	53	0.2	0.7
12008															
1976	15	0.001	0.003	15	0.012	0.029	15	0.26	0.45	15	3.3	6.9	15	0.7	1.3
1977	18	0.008	0.025	18	0.018	0.074	18	0.42	1.07	18	4.0	11.1	18	0.8	1.7
1978	23	0.004	0.019	23	0.017	0.045	23	1.13	2.55	23	3.1	9.0	23	0.6	1.8
1979	34	0.004	0.023	34	0.008	0.036	34	0.49	1.62	34	1.9	6.3	34	0.4	1.0
1980	24	0.002	0.008	24	0.004	0.012	24	0.38	1.18	25	1.7	4.1	51	0.4	1.1
1981	307	0.003	0.042	307	0.005	0.043	307	0.15	0.82	307	1.6	7.2	316	0.4	2.0
1982	318	0.003	0.027	317	0.005	0.024	319	0.14	0.68	295	1.2	5.4	313	0.3	1.3
1983	328	0.002	0.025	328	0.004	0.015	328	0.29	1.64	328	1.2	5.5	328	0.3	0.9
1984	344	0.003	0.031	343	0.005	0.117	344	0.21	2.24	344	1.5	5.9	345	0.3	1.1

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12009															
1978													53	0.4	1.4
1979													47	0.2	0.8
1980													53	0.2	0.7
1981													43	0.1	0.4
1982													53	0.1	1.0
1983													53	0.2	0.8
1984													56	0.1	0.5
12010															
1976	12	0.001	0.006	12	0.008	0.026	12	0.12	0.52	12	1.6	5.2	12	0.4	1.0
1977	20	0.002	0.006	20	0.009	0.029	20	0.08	0.24	20	1.2	5.5	20	0.4	0.9
1978	24	0.002	0.007	24	0.007	0.020	24	0.13	0.44	24	1.0	2.5	24	0.3	1.2
1979	32	0.002	0.005	32	0.003	0.015	32	0.19	0.79	32	0.9	2.1	32	0.2	0.6
1980	23	0.002	0.006	23	0.003	0.007	23	0.09	0.21	24	0.5	1.7	23	0.2	0.7
1981	55	0.002	0.012	55	0.004	0.031	55	0.10	0.50	55	0.9	4.4	55	0.2	0.6
1982	57	0.002	0.005	56	0.002	0.009	57	0.14	0.30	52	0.5	1.8	55	0.2	0.8
1983	33	0.001	0.004	33	0.002	0.009	33	0.10	0.22	33	0.5	1.4	33	0.2	0.5
1984	32	0.001	0.004	32	0.004	0.024	32	0.05	0.09	32	0.4	1.0	32	0.2	0.7
12013															
1976	17	0.006	0.035	17	0.028	0.113	17	0.15	0.28	22	5.8	21.9	17	0.8	2.0
1977	19	0.007	0.033	19	0.033	0.101	19	0.14	0.35	24	7.2	26.3	19	0.8	1.8
1978	23	0.003	0.012	23	0.032	0.116	23	0.09	0.26	57	6.6	23.1	23	0.5	1.0
1979	22	0.002	0.009	22	0.016	0.055	22	0.13	0.60	56	5.5	29.5	22	0.5	0.9
1980	11	0.001	0.002	11	0.009	0.025	11	0.12	0.37	49	2.6	7.7	11	0.3	0.7
1981	53	0.002	0.011	53	0.008	0.029	53	0.14	0.31	56	1.8	6.4	53	0.3	1.2
1982	56	0.003	0.014	56	0.016	0.089	56	0.24	0.63	53	2.6	8.3	54	0.3	1.3
1983	56	0.002	0.011	56	0.009	0.044	56	0.14	0.34	56	3.2	16.2	56	0.2	0.7
1984	58	0.002	0.008	58	0.008	0.056	58	0.08	0.26	58	3.9	22.2	58	0.2	0.6

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12015															
1978										55	4.0	15.4			
1979										48	3.9	11.3			
1980										52	3.0	8.3			
1981	58	0.004	0.022	57	0.009	0.037	57	0.13	0.29	57	2.5	5.8	57	0.3	1.4
1982	53	0.005	0.074	53	0.008	0.059	53	0.20	3.09	52	2.1	27.1	52	0.2	0.8
1983	57	0.002	0.009	57	0.004	0.020	57	0.15	0.75	57	1.8	6.4	57	0.2	1.0
1984	47	0.003	0.027	47	0.006	0.019	47	0.22	0.78	47	2.5	8.0	47	0.1	1.0

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Chloride # of samples	Chloride Avg.	Chloride Max.	Iron # of samples	Iron Avg.	Iron Max.	Lead # of samples	Lead Avg.	Lead Max.
12016									
1978				56	3.8	12.5			
1979				52	3.1	10.1			
1980				52	2.6	6.2			
1981				10	1.7	3.3			
1982				54	1.5	6.3			
1983				73	1.5	4.0			
1984				120	1.4	6.0	69	0.3	1.1
12032									
1976				40	4.1	8.4	15	0.5	1.3
1977				29	3.5	17.9	26	0.5	0.9
1978				49	3.1	9.6	37	0.4	2.1
1979				43	3.6	9.6	58	0.3	1.4
1980				32	2.3	5.8	33	0.3	0.6
1981				56	1.4	8.2	57	0.2	0.4
1982				54	1.4	6.3	55	0.2	0.8
1983				57	1.7	6.4	57	0.2	0.9
1984				18	1.3	3.3	18	0.1	0.1
12039									
1978				33	6.3	55.8			
1979				56	3.4	24.6			
1980				54	3.1	37.0			
1981				59	1.8	10.4			
1982				52	1.5	12.4			
1983				58	2.6	14.0			
1984				56	2.3	24.8			
12015									
1984	49	3.6	21.5						

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
12002															
1976	12	0.12	0.22	12	0.013	0.027	54	4.9	11.8	54	9.5	35.1	12	0.02	0.03
1977	20	0.11	0.32	20	0.025	0.073	56	4.9	21.6	56	12.5	35.5	20	0.04	0.14
1978	24	0.14	1.10	24	0.016	0.034	52	6.3	20.5	52	14.1	41.1	24	0.00	0.02
1979	28	0.08	0.20	28	0.009	0.015	49	6.8	17.8	49	13.4	28.4	28	0.00	0.03
1980	23	0.05	0.14	23	0.010	0.026	53	6.6	16.9	53	13.8	55.9	23	0.01	0.01
1981	55	0.06	0.20	55	0.011	0.070	58	7.0	19.4	57	13.1	29.7	12	0.01	0.02
1982	51	0.05	0.11	51	0.007	0.027	45	5.4	15.6	51	11.2	37.4	55	0.01	0.02
1983	33	0.04	0.11	33	0.004	0.020	54	4.8	14.5	54	9.7	27.5	33	0.00	0.01
1984	34	0.06	0.14	34	0.003	0.008	57	4.1	10.8	57	9.5	25.5	34	0.01	0.02
12005															
1981	50	0.04	0.34	58	0.008	0.085	59	4.9	11.1	58	10.6	28.8	50	0.01	0.03
1982	53	0.03	0.10	54	0.011	0.085	44	4.0	10.1	48	10.5	34.3	54	0.00	0.02
1983	52	0.03	0.11	52	0.004	0.017	52	3.6	11.0	52	9.3	29.6	50	0.00	0.01
1984	52	0.04	0.40	49	0.004	0.036	53	4.0	9.2	53	9.3	21.7	53	0.00	0.02
12008															
1976	15	0.11	0.28	15	0.051	0.409	105	4.8	21.6	104	10.7	39.7	15	0.17	1.47
1977	18	0.19	0.48	18	0.026	0.084	48	5.2	23.5	48	13.4	34.2	18	0.03	0.10
1978	23	0.12	0.31	23	0.026	0.059	55	5.3	20.5	55	14.3	57.1	23	0.00	0.03
1979	34	0.07	0.22	34	0.010	0.027	58	6.0	15.7	58	13.7	40.5	34	0.00	0.01
1980	24	0.06	0.15	24	0.014	0.049	52	5.5	16.2	52	11.8	31.0	24	0.01	0.01
1981	307	0.06	0.25	296	0.008	0.041	305	4.9	19.8	297	10.4	44.5	307	0.01	0.03
1982	319	0.04	0.23	318	0.007	0.071	267	4.6	17.3	268	10.4	50.5	319	0.01	0.03
1983	328	0.04	0.17	306	0.005	0.084	328	4.0	13.2	328	9.5	41.7	328	0.01	0.02
1984	344	0.06	0.37	343	0.007	0.234	344	4.5	17.4	332	8.9	28.6	343	0.01	0.14
12009															
1979							24	5.2	13.4	24	11.8	25.4			
1980							55	5.3	17.5	55	11.6	24.6			
1981							43	4.5	13.7	41	10.2	26.4			
1982							53	4.1	12.7	53	10.6	32.4			
1983							55	4.1	12.0	55	9.1	20.3			
1984							56	3.7	8.9	56	8.7	25.1			

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
12010															
1976	12	0.06	0.19	12	0.003	0.021	51	3.6	14.2	51	6.9	31.9	12	0.01	0.01
1977	20	0.04	0.20	20	0.019	0.035	52	4.4	24.5	52	10.3	25.4	20	0.01	0.02
1978	24	0.03	0.09	24	0.008	0.019	55	4.5	25.2	55	11.5	44.1	24	0.00	0.00
1979	32	0.03	0.07	32	0.005	0.011	54	5.1	12.6	54	11.5	30.3	32	0.00	0.02
1980	23	0.02	0.05	23	0.004	0.008	53	4.8	10.8	53	10.8	23.5	23	0.00	0.01
1981	55	0.04	0.42	55	0.004	0.018	58	4.5	14.3	58	11.1	36.4	55	0.00	0.02
1982	56	0.02	0.09	57	0.006	0.018	56	3.1	9.7	56	8.8	19.8	57	0.00	0.05
1983	33	0.02	0.04	33	0.003	0.014	33	3.2	10.3	33	8.2	19.3	33	0.01	0.02
1984	32	0.02	0.05	27	0.007	0.105	32	2.9	11.2	32	9.1	24.6	32	0.00	0.03
12013															
1976	17	0.38	1.94	17	0.004	0.029	59	4.5	15.0	59	8.3	21.0	17	0.01	0.02
1977	19	0.39	2.02	19	0.031	0.069	54	6.1	32.0	54	13.1	33.6	19	0.02	0.07
1978	23	0.24	0.95	23	0.013	0.058	56	6.6	22.8	56	14.7	48.4	23	0.00	0.03
1979	22	0.15	0.38	22	0.011	0.025	56	7.2	22.9	56	15.0	41.9	22	0.00	0.01
1980	11	0.11	0.47	11	0.007	0.012	54	6.0	19.4	54	13.0	26.9	11	0.01	0.01
1981	53	0.06	0.20	53	0.004	0.017	56	6.3	14.7	56	14.1	33.8	53	0.01	0.02
1982	56	0.15	0.92	56	0.009	0.029	56	4.8	15.4	56	10.9	35.0	56	0.01	0.04
1983	56	0.15	1.14	56	0.006	0.024	32	4.6	12.5	32	9.6	23.4	56	0.00	0.02
1984	58	0.15	0.83	53	0.007	0.031							58	0.00	0.02
12015															
1981	52	0.08	0.22	57	0.008	0.047	55	6.0	17.3	55	14.3	32.3	51	0.01	0.02
1982	52	0.05	0.15	53	0.010	0.102	51	4.6	15.1	51	11.7	28.0	53	0.01	0.13
1983	57	0.05	0.14	57	0.004	0.020	43	4.5	13.8	43	10.8	27.5	57	0.01	0.07
1984	47	0.09	0.27	47	0.005	0.023	47	5.7	14.3	47	13.7	40.6	47	0.00	0.02
12032															
1981							57	5.5	18.1	55	13.6	29.3			
1982							55	4.4	14.1	55	11.0	32.2			
1983							57	4.5	13.7	57	11.3	26.3			
1984							18	5.1	8.8	18	10.0	20.9			

APPENDIX 3

TOTAL REDUCED SULPHUR, CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS AND OZONE

Table A5. Summary of data for total reduced sulphur, carbon monoxide, oxides of nitrogen, hydrocarbons and ozone.

Parameter	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Station 12032													
Total reduced sulphur	(c)												
Annual average (ppb)	0.1	0.4	0.1	0.5[a]									
Percentage of values greater than:													
1-hour criterion	0.11	0.02	0.01	0.06									
Station 12007													
Total reduced sulphur	(d)												
Annual average (ppb)	1.3												
Percentage of values greater than:													
1-hour criterion	0.70												
Station 12013													
Total reduced sulphur	(d)												
Annual average (ppb)	1.5												
Percentage of values greater than:													
1-hour criterion	0.00												

(a) 8 months of data

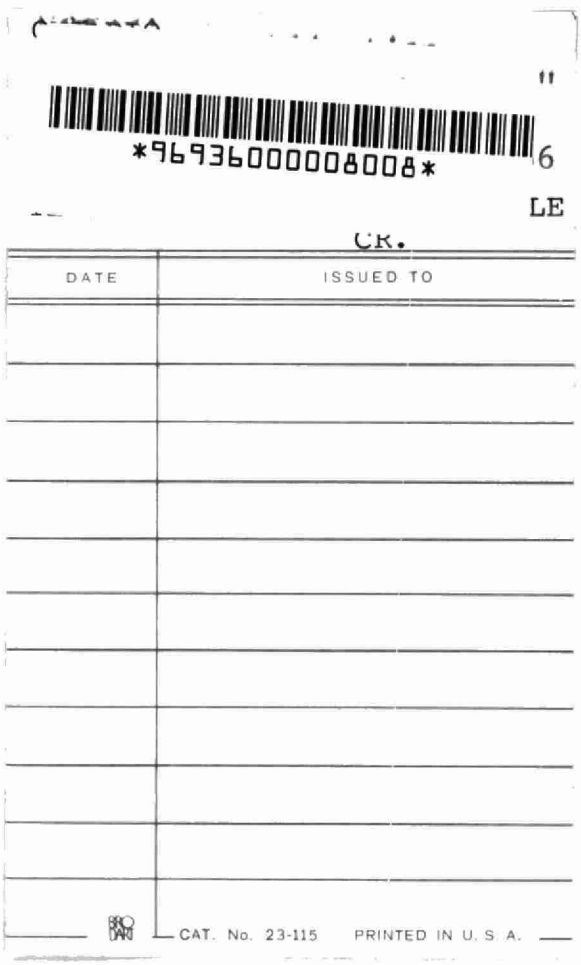
(b) 9 months of data

(c) 4 months of data

(d) 7 months of data

Table A5. continued

Parameter	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Station 12008													
Carbon monoxide													
Annual average (ppm)	1	1	1	1	2	2	2	2	4	5	5	5	5
Percentage of values greater than:													
1-hour criterion	0	0	0	0	0	0	0	0	0	0	0	0.01	0
8-hour criterion	0	0	0	0	0	0	0	0	0	0.32	0.30	0.10	0
Nitrogen dioxide													
Annual average (ppm)	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03		
Percentage of values greater than:													
1-hour criterion	0	0	0	0	0	0	0.01	0	0	0	0		
24-hour criterion	0	0	0	0	0	0	0	0	0	0			
Nitric oxide													
Annual average (ppm)	0.03	0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04		
Total oxides of nitrogen													
Annual average (ppm)	0.05	0.04	0.04	0.05	0.05	0.05	0.07	0.07	0.06	0.06	0.07		
Total hydrocarbons													
Annual average (ppm)	2.3	2.1	2.1	2.1	2.2	1.9[(b)]	2.3	2.4	2.6	2.2	1.9	2.1	2.2
Reactive hydrocarbons													
Annual average	0.4	0.3	0.4	0.4									
Ozone													
Annual average (ppm)	0.019	0.019	0.018	0.019	0.020	0.016	0.018	0.021	0.021	0.017	0.014		
Percentage of values greater than 1-hour criterion	1.7	1.4	0.6	1.3	1.8	0.8	2.4	3.1	2.5	2.2	0.8		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